Renewable and Sustainable Energy Reviews 15 (2011) 2457–2460

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Small wind power in China: Current status and future potentials

Sufang Zhang*, Jianxun Qi

School of Economics and Management, North China Electric Power University, #2 Beinong Road, Zhuxinzhuang Deshengmenwai, Beijing 102206, China

ARTICLE INFO

Article history:
Received 19 October 2010
Accepted 31 January 2011

Keywords:
Renewable energy
Small wind power
Sustainable development

ABSTRACT

This paper firstly presents an overview of wind energy potential in China and discusses the features of small wind power system deployment. Then it reviews the current status of small wind power development in China. The future perspectives of and barriers to small wind power development in China are predicted and analyzed. Finally some policies for promoting small wind power development in China are recommended. This study provides a comprehensive overview of the current status of small wind power in China and some insights into the prospects of small wind power market in China.

Contents

1. Introduction

China is rich with wind power resources. According to the China Meteorological Administration, onshore wind power resources at an altitude of 10 m total about 3226 GW in terms of electricity, including 253 GW available for development and utilization. At an altitude of 50 m, the resources available for development and utilization double to more than 500 GW. Offshore wind power resources in coastal waters aggregate 750 GW [1].

As indicated in Fig. 1, regions rich with wind power resources in China are as follows: (1) Three northern regions (Northeast, North and Northwest): Within a radius of 200 km in three northeastern provinces (Jilin, Heilongjiang and Liaoning), Hebei Province, Inner Mongolia Autonomous Region, Gansu Province, Ningxia Autonomous Region, Xinjiang Uygur Autonomous Region, etc. The annual wind power energy density ranges from 200 to more than 300 W per square meter; (2) Southeastern coastal waters and islands: Coastal waters within some 10 km from the coast in Shandong Province, Jiangsu Province, Shanghai municipality, Zhejiang Province, Fujian Province, Guangdong Province, Guangxi Autonomous Region, Hainan Province, etc. The annual wind power energy density exceeds 200 W per square meter; (3) Inland regions:

* Corresponding author. Tel.: +86 1013552847009; fax: +86 10 80796904.
E-mail address: zsf69826313@sina.com.cn (S. Zhang).

1364-0321/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.rser.2011.02.009

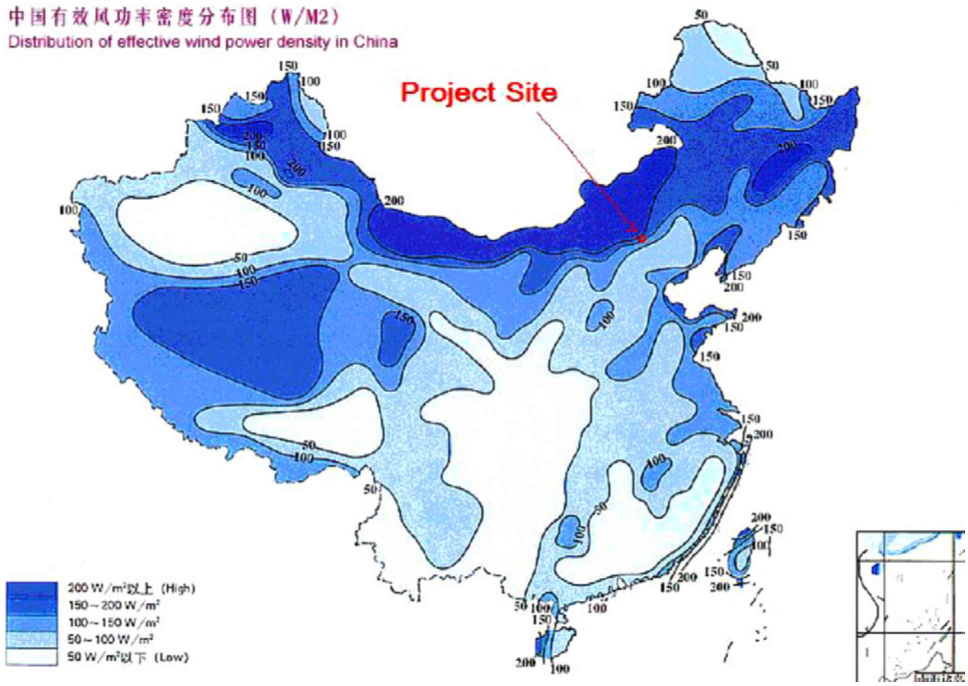


Fig. 1. Distribution of the effective wind power density in China.

Source: China Meteorological Administration.

Lake Poyang and its vicinity, Mt. Jiugong and Lichuan River in Hubei Province, etc.; (4) Coastal waters: Eastern China coastal waters with depths from 5 to 20 m. Wind power resources are estimated at about 700 GW [2].

2. Features of small wind power system deployment

The distribution of wind power resources mentioned above illustrates the wind distribution on macro-level in China, which is significant for constructing large wind farms and developing large wind power industry. It is also significant for the development of small wind power. However, small wind power systems have its own features in terms of exploitation of wind power.

2.1. Fewer requirements

Deployment of small wind power systems (normally with a rated capacity of less than 100 kW) requires neither strong infrastructure support nor special equipments (e.g., large trucks and heavy cranes) to transport and install big components (e.g., towers, turbine nacelles, and long blades). Small wind power systems need only small foundation plots. Land acquisition and resettlements are rare. It is less knowledge-intensive and skill-demanding to install, operate, maintain, and repair these small systems. They can be implemented in a modular way within a few months and do not involve high speed, temperature, pressure, voltage or loads.

2.2. Avoid substantial investment

Deployment of small wind power systems avoids the substantial investment needed for generating, transmitting, and distributing electricity produced from centralized combustion of fossil fuels. Financial costs and environmental damage embedded in line losses (normally more than 10% for rural consuming end points) in voltage conversion and long distance transmission are eliminated, when electricity is produced and consumed in the same neighborhood. In places where rich wind resources cannot be harnessed by constructing large-scale wind farms—because of infrastructure bottlenecks, impossible grid integration, or lack of capacity to handle large power projects—these small systems can provide a practical solution in helping utilize indigenous renewable resources more quickly and effectively to supply clean, reliable, and affordable electricity to reduce poverty in poor rural communities.

3. Current status of small wind power in China

3.1. Enterprises and jobs offered

According to an incomplete statistic, by the end of 2008, there were 102 enterprises with relation to small wind power industry in China, of which about 74 enterprises were engaged in manufacturing and R&D (36 were main small wind turbine manufacturers), 28 enterprises were parts and components suppliers, and 10 units were universities and research institutes. Direct jobs offered by this industry were 4500–5000 (not including the parts and components suppliers), and 25% of the employees were engineers or technicians.

3.2. Varieties of small wind turbines

By the end of 2008, there were 19 varieties of small wind turbines produced in China with unit capacities of: 100 W, 150 W, 200 W, 300 W, 400 W, 500 W, 600 W, 1 kW, 2 kW, 3 kW, 4 kW, 5 kW, 10 kW, 15 kW, 20 kW, 25 kW, 30 kW, 50 kW and 100 kW. In 2008, the installed capacity value, profit and tax of small wind turbines with unit capacity less than 100 kW totaled 72825 kW, 518.901 million yuan and 99.4854 million yuan respectively.

3.3. Output, production capacity and exports

Based on the statistics released by the Chinese Wind Energy Equipment Association, the various kinds of small wind turbines produced by manufacturers in China accumulated to 508712 units from 1983 to 2008 (see Table 1 and Fig. 2) [3]. China ranked the first

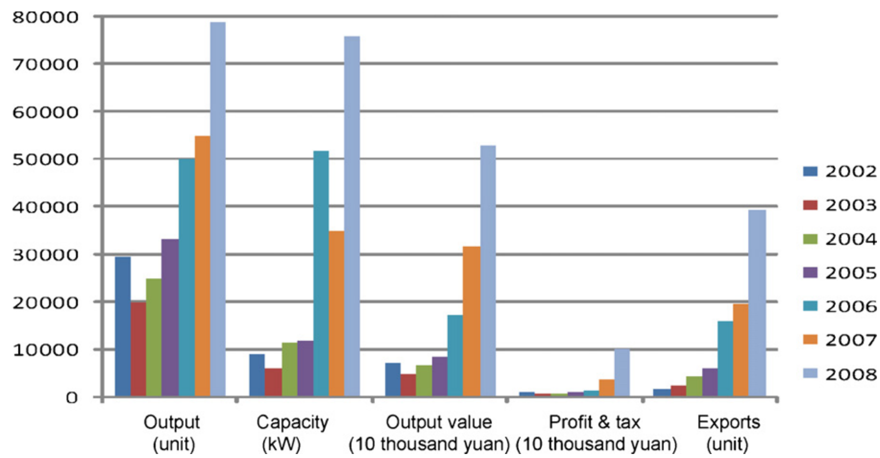


Fig. 2. Output, capacity, output value, profit and tax, exports of small wind turbines in China (2002–2008).

Table 1
Output of small wind turbines in China (before 1983–2008).

Year	Output (unit)	Year	Output (unit)	Year	Output (unit)
Before 1983	3632	1992	5537	2001	20,879
1984	13,470	1993	6100	2002	29,758
1985	12,989	1994	6481	2003	19,920
1986	19,151	1995	8190	2004	24,756
1987	20,847	1996	7500	2005	33,253
1988	25,575	1997	6123	2006	50,052
1989	16,649	1998	13,884	2007	54,843
1990	7458	1999	7096	2008	78,411
1991	4988	2000	12,170	Total	509,712

in the world in terms of annual output, total output, production capacity and exports (see Table 2 and Fig. 2) [3].

According to a conservative estimation, there are at present about 200,000 units in operation in China. If the average power of each small wind turbine is supposed to be 500 W, the installed capacity in China is about 100 MW accounting for only 0.0126% of the national total installed capacity of wind power generation. If each small wind turbine works 5 h per day at its rated capacity, the power generation of 200,000 small wind turbines will be 1825 million kW h per year accounting for 0.0053% of the total generation in China. Therefore, in terms of both installed capacity and generation, small wind power industry is too trivial or insignificant to mention in the energy industry and green energy in China.

In the light of the export statistics of 19 major export manufacturers in China, the exports of small wind turbines with a capacity less than 100 kW totaled 38957 units in 2008, increased by 197.5% from the year 2007 with a total value of US$44.6766 million. The cumulative exports of the recent ten years reached 92145 units. Small wind turbines have been exported to 46 countries or regions, including South Korea, India, Mongolia, Thailand, the Philippines, Indonesia, Singapore, Vietnam, Kazakhstan, Japan, Turkey, Israel, Lebanon, Malaysia, Syria, France, Britain, Russia, Netherlands, Ireland, Denmark, Spain, Belgium, Sweden, Germany, Italy, Poland, Scotland, Greece, Finland, Croatia, the United States, Canada, Chile, Ecuador, Mexico, Dominican Republic, Brazil, Australia, New Zealand, Nigeria, Kenya, Guinea, Hong Kong and Taiwan. Major exporters of small wind turbines in China are YangZhou, Shenzhou, Guangzhou Hongyin, Hunan Zkenergy, Ningbo Fengshen, Qingdao Anhua, Zhejiang Huaying, etc. [3].

Table 2
Comparison between centralized generation and distributed generation in terms of greenhouse gas emission reduction.

Emission	100% centralized generation	100% distributed generation	Reduction by distributed generation	Percentage change
NO_2	917	99	819	89%
SO_2	910	97	813	89%
Particles	48	20	28	58%
CO_2	739	322	416	56%

Source: World Alliance for Decentralized Energy.

3.4. Application of small wind turbines

The conventional users of small wind turbines in China are farmers, herdsmen and fishermen who live in areas without electricity or lacking electricity. Now small wind turbines are being applied to much broader fields such as highway and railway monitoring, marine traffic control, weather stations, TV transpose stations, medical and health.

4. Prospects for small wind power development in the China

The future development of small wind power in China is bright because of great potential domestic and foreign markets and the many positive social, economic as well as environmental effects it could bring about.

4.1. Potential markets

At present, there are 11.47 million populations still living in regions without electricity in China, at least 40% of which can be electrified by small wind turbines. What's more, there is a large population in Southeast Asia, South Asia and Africa without electricity.

It is well documented that nearly one billion poor people in the Asia and Pacific region are still being trapped in poverty, without access to modern energy that is crucial for job and income opportunities and for delivery of basic education, health and communication services. Many of these poor people are living in remote mountainous areas (e.g., Afghanistan, Nepal, and parts of India), deserts and grasslands (e.g., the northwestern region of the People's Republic of China), and ocean islands (e.g., Indonesia, Philippines, Sri Lanka, and Pacific Islands). In many cases, it is technically difficult and prohibitively expensive to connect these remote underdeveloped areas with low volumes of electricity consumption to the power grid.

Nevertheless, these remote areas are often endowed with abundant and inexhaustible wind resources. For instance, about 75% of

the China's rich onshore wind resources are concentrated in the northwestern grasslands and the Gobi Desert, stretching from Inner Mongolia through Hebei, Ningxia, and Gansu to Xinjiang. Within this narrow strip of about 200 km, the wind power density normally ranges from 200 W/m^2 to 300 W/m^2 and can reach above 500 W/m^2 in some regions with more favorable conditions. Up to now, most of these valuable resources have not been properly utilized, and thus remain de-facto wasted.

4.2. Social, economic and environmental effects of small wind power

4.2.1. Social effects

Without linkages to power grids, local schools, hospitals, processing plants, shops, and other public, commercial, and residential facilities have to rely on diesel generation, while diesel must be imported from far-away places, hauled over long distances, and stockpiled at high inventory. Fuel shortage, vulnerability to rising and volatile oil prices, lack of essential spare parts, and inadequate maintenance can frequently interrupt diesel power supply, resulting in inferior service quality, high operation costs, and heavy environmental pollution. The number of families in villages without electricity could actually increase if the population growth rate outpaces the rural electrification rate. Even a small amount of electricity, provided by tapping into local resources such as wind, would light up lives of many poor people in remote areas [4].

The experience of China in the past three decades in utilizing small wind power shows that the social effects of small wind power are remarkable. From early 1980s to the present, varieties of small wind turbines including 100 W, 200 W, 300 W, 500 W, 1 kW, 2 kW, 5 kW and 10 kW have been gradually applied in pasturing areas, remote rural areas and lake areas. With electricity generated by small wind turbines, farmers, herdsmen and fishermen in areas without access to grids now have lighting and students are able to read, do homework and families can watch TV enjoying rich and colorful culture life. It may be said that small wind turbines have brought modern civilization to these areas.

4.2.2. Economic effects

Small wind power systems not only bring about social effects but also promote local economic development. On the one hand, they increase existing enterprises' production capability; on the other hand, they provide new small enterprises with opportunities. The most common small businesses are retailers and processing firms whose activities have doubtlessly promoted local economic development.

4.2.3. Environmental effects

Currently China generates most of its electricity in large centralized facilities, such as fossil fuel (coal, gas powered) nuclear or hydropower plants. These plants have excellent economies of scale, but usually transmit electricity long distances and negatively affect the environment. Distributed generation, also called on-site generation (such as small wind power generation) reduces the amount of energy lost in transmitting electricity because the electricity is generated very near where it is used. For those poor communities in China without access to electricity but with abundant wind resources, distributed small wind power systems provide a realistic option to convert untapped indigenous renewable energy resources to reliable electricity supply at zero fuel costs and free of greenhouse gas emissions. The environmental effects of distributed generation are illustrated in Table 2.

5. Barriers to small wind power development in China and policy recommendations

5.1. Barriers

Small wind power is a renewable energy industry with a development history of more than three decades in China, and it has made great contributions in resolving the issue of electricity for people in the regions without electricity in China. However, in most cases, these contributions were subsidized as general welfare by the government. In China, small wind power used to be promoted as one of the "Three Small Powers", i.e. small wind power, small PV, small hydropower in rural areas featured with government interference and poverty-alleviation for agricultural population. The government granted a certain amount of subsidy to end-users and required small wind turbine manufacturers to "contribute" and to pursue a "low profit rate".

The result of this policy is that the enterprises went into difficulties, struggling to survive and lacking development potential. In addition, the capacity of single small wind turbine is small and the price is low, all the modern advanced technologies applied in large wind turbines can not be used in small wind turbines due to the cost.

In recent years, the Chinese government has attached great importance to the development of renewable energy and issued a series of regulations and incentives to promote the use of renewable energy. Unfortunately, none of them benefits small wind power industry.

5.2. Policy recommendations

Technological gap for small wind power industry between China and international advanced level is not big as China has its own intellectual property rights with regard to small wind power technology [5]. If the government grants incentive policies similar to those granted to large wind industry and PV Industry, maintains stable, continuous and long-term policies and lets enterprises and users see the prospect of the industry, small wind industry could develop in two directions, off-grid distributed generation and on-grid distributed generation, and the annual installed capacity could reach about 1 GW (off-grid) and several GW (on-grid) respectively.

For the purpose of promoting the development of small wind power industry in China, the following policies are recommended: (1) Relevant state departments should attach more importance to small wind power industry. Strategies and concrete measures for promoting small wind power industry should be drawn up or taken; (2) Medium and small wind turbines should be allowed to connect to grid; (3) The application of distributed generation technology should be promoted; (4) Incentive policies and measures such as assistance should be promulgated so as to promote the deployment of such a useful low carbon technology.

References

[1] Ni C. China Energy Primer, http://www.osti.gov/bridge/servlets/purl/979807-XSkUoh/. Nov. 2009, p. 25.
[2] Chuanchuan N. China's wind-power generation policy and market development. IEEJ 2008. http://www.eaber.org/intranet/documents/96/1084/IEEJ_Ni_2008.pdf.
[3] Zhijie D, Fang L, Zhenbin, C. et al., China Small Wind Power Industry Development, Survey and Analysis Report (in Chinese), http://toolkits.reeep.org/file_upload/107030534_2.pdf.
[4] ADB. Effective Deployment of Distributed Small Wind Power Systems in Asian Rural Areas, www.adb.org/Documents/TARs/REG/43458-REG-TAR.pdf.
[5] Zhijie D. National Policy, Strategy and Roadmap Study for China Small Wind Power Industry Development (PPT, in Chinese).